GENERATING DOWNHOLE POWER

DESCRIPTION

BACKGROUND

[Para 1] The invention generally relates to generating downhole power.

[Para 2] A typical subterranean well includes various devices that are operated by mechanical motion, hydraulic power or electrical power. For devices that are operated by electrical or hydraulic power, control lines and/or electrical cables typically extend downhole for purposes of communicating power to these tools from a power source that is located at the surface. A potential challenge with this arrangement is that the space (inside the wellbore) that is available for routing various downhole cables and hydraulic control lines may be limited. Furthermore, the more hydraulic control lines and electrical cables that must be installed and routed downhole, the higher probability that some part of the power delivery infrastructure may fail.

[Para 3] Thus, some subterranean wells have tools that are powered by downhole power sources. For example, a fuel cell is one such downhole power source that may be used to generate electricity downhole. The subterranean well may include other types of downhole power sources, such as batteries, for example.

[Para 4] A typical subterranean well undergoes a significant amount of vibration (i.e., vibration on the order of Gs, for example) during the production of well fluid. In the past, the energy produced by this vibration has not been captured. However, an emerging trend in subterranean wells is the inclusion of devices to capture this vibrational energy for purposes of converting the energy into a suitable form for downhole power.

[Para 5] Thus, there is a continuing need for better ways to generate power downhole in a subterranean well.

SUMMARY

[Para 6] In an embodiment of the invention, a system that is usable with a subterranean well includes a first tubular member that is adapted to receive a flow of a first fluid. The system includes a second tubular member that is located in the flow and is substantially flexible to be moved by the flow to establish a pressure on a second fluid located inside the tubular member. A mechanism of the system uses this pressure to actuate a downhole tool.

[Para 7] Advantages and other features of the invention will become apparent from the following description, drawing and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[Para 8] Fig. 1 is a schematic diagram of a well according to an embodiment of the invention.

[Para 9] Figs. 2, 3 and 4 depict a pump of Fig. 1 for different positions of a flexible tube of the pump according to an embodiment of the invention.

[Para 10] Fig. 5 is a block diagram of a hydraulic system according to an embodiment of the invention.

[Para 11] Fig. 6 is a flow diagram depicting a technique to harness downhole energy according to an embodiment of the invention.

DETAILED DESCRIPTION

[Para 12] Referring to Fig. 1, an embodiment 10 of a subterranean well in accordance with the invention includes a wellbore 12 that extends downhole through one or more subterranean formations. In the example depicted in Fig. 1, the system 10 may include a tubular string 14 (a production tubing, for example) that extends into the wellbore 12. In the exemplary system 10 depicted in Fig. 1, the well is uncased. However, in other embodiments of the invention, the wellbore 12 may be lined by a casing string. A packer 30 may seal and anchor the tubular string 14 to the wellbore 12.

[Para 13] The tubular string 14, in some embodiments of the invention, is a production tubing string that includes a central passageway 29 that receives the flow of production fluid from the well. For example, as depicted in Fig. 1, the tubular string 14 may receive the flow of well fluid (depicted generally by the

arrows 27) from one or more zones, such as exemplary zone 32.

[Para 14] More specifically, the fluid flows from the zone 32 up through the central passageway 29 and returns to the surface of the well. Although Fig. 1 depicts a vertical well, it is understood that in other embodiments of the invention, the well 10 may include various lateral, or horizontal, wellbores. Thus, the well 10 is merely depicted as an example to illustrate the harnessing of power, described below.

[Para 15] In some embodiments of the invention, the tubular string 14 includes a pump 16 that harnesses energy that is generated or induced by the flow of production fluid through the tubular string 14. More specifically, in some embodiments of the invention, the pump 16 is a "lymphatic pump," in that the pump 16 directly converts energy induced by the flow or well fluid into hydraulic power that may be used to control one or more downhole tools of the string 14.

[Para 16] More specifically, in some embodiments of the invention, the pump 16 exerts hydraulic pressure on fluid that is stored in an accumulator 20 of a hydraulic system 18 of the string 14. The pressure accumulated in the accumulator 20, in turn, is used by the system 18 to drive, or actuate, one or more downhole tools 24 (one tool 24 being depicted in Fig. 1) of the tubular string 14. Depending on the particular embodiment of the invention, the tool 24 may be a sleeve, a valve, a packer, etc.

[Para 17] In some embodiments of the invention, the pump 16 may have a form that is generally depicted in Fig. 2. In particular, the pump 16 includes a substantially flexible

tubular member 50 that is located inside the central passageway 29 of the tubular member 14. For example, in some embodiments of the invention, one end of the tubing 50 may be a free end 46, in that the end 50 moves with the flow 27. The opening at the end 46 is generally concentric with the longitudinal axis of the central passageway 29. Thus, a portion 51 of the flow 27 is diverted into the tubing 50 to create a flowpath from the end 46 to a distal end 48 of the flow tube 50. The pressure of this flow 51, in turn, is affected by the movement of the flow tube 50.

[Para 18] More specifically, in some embodiments of the invention, the flow tube 50 moves due to the flow 27, as depicted in Figs. 2, 3 and 4 for three different positions of the flow tube 50. This waving action of the flow tube 50 serves to pump the flow 51 to pressurize fluid in the flow 51. It is this pressure that may be used to actuate one or more downhole tools.

[Para 19] Referring to Fig. 5, in some embodiments of the invention, the hydraulic system 18 may have a form like the one generally depicted in Fig. 5. In the system 18, the end 48 of the flow tube 50 communicates the flow 51 to an accumulator 100. The accumulator 100 may include, for example, a first chamber in communication with the flow 51 that is separated from a second chamber, containing a hydraulic control fluid, by a piston, for example. Thus, the accumulation of pressure from the flow 51 establishes a control pressure in a hydraulic output line 101 of the accumulator 100. In some embodiments of the invention, the hydraulic output line 101 may be connected through a check

valve 107 to a pressurized source 120. Thus, the accumulator 100 may serve to pressurize a particular source 120 for purposes of forming a direct hydraulic power source. A hydraulic control circuit 102 is in communication with the pressurized source 120 for purposes of controlling when this pressurized source is applied to one or more downhole tools via hydraulic output lines 108. Other variations are possible and are within the scope of the appended claims.

[Para 20] Referring to Fig. 5, in some embodiments the hydraulic control also includes a maximum pressure relief valve 110 that provides an upper limit on the pressurized source. In some embodiments of the invention, the hydraulic system 18 may be a closed system in that the maximum pressure relief valve 110 is connected to a chamber to effectively "store" a maximum pressure in the well. This chamber may be used to power one or more downhole tools, for example.

[Para 21] Thus, referring to Fig. 6, in some embodiments of the invention, a technique 200 may be used for purposes of performing a particular downhole function. Pursuant to the technique 200, a flow of well fluid is directly converted into hydraulic pressure, as depicted in block 202. The hydraulic pressure is then used (block 204) to perform some downhole function. For example, this downhole function may be the actuation of a valve, the movement of a sleeve, the setting of a packer, etc.

[Para 22] While the present invention has been described with respect to a limited number of embodiments, those skilled in the art, having the benefit of this disclosure, will appreciate

numerous modifications and variations therefrom. It is intended that the appended claims cover all such modifications and variations as fall within the true spirit and scope of this present invention.